

RESTORATION

Identify best candidates
for **restoration**

Countless ways to do this. Propose 'core components' (that apply beyond our study area) and discuss ways that existing resources, such as the BCG, B-IBI, IWI/ICI, RCP, WSIO, can be used to help prioritize sites.
Discuss policy questions that arise during this process (e.g., invest in fair vs totally hammered sites = more bang for the buck?).
Discuss adding a CC component (what would this look like, and how would it influence prioritization?).
Discuss how this process is valuable even if local factors (e.g., land ownership) end up swamping these considerations in the end.



Stressor ID

Evaluate IWI components? Hydrologic regulation, chemistry, sediment, hydrologic connectivity, temperature, habitat; also evaluate the associated 'major stressor' StreamCat inputs?
Biology: develop lists of indicator taxa for specific stressors (note: these already exist for sediment tolerance & thermal tolerance in our dataset).



Select restoration
strategy

Is there a compendium with information on which strategies work best for a given stressor (or suite of stressors?); if not, we should advocate for the creation of an accessible repository of this information.
Also consider biological restoration goals & how they are defined... our BCG work on Level 1/historic condition could be helpful here (if BCG level 1 isn't a reasonable attainment goal, where should we set the bar?)
Consider the scale of the project (and level of disturbance) when setting goals and timelines



Adaptation design
tool?

This is a tool that was developed for corals but can be applied to streams; it takes you through a formal process (with worksheet templates) during which you consider how climate change factors into your restoration strategies



Implementation



Measure effectiveness
(with biology)

B-IBI and BCG. Too coarse for short-term indicators?
Develop specific indicator metrics for short-term indicators?
Climate change considerations too? (e.g., modify metrics to include thermal tolerance, similar to what we did for the BCG climate pilot).
What do we know about timelines for biology (expect 5-10 years if certain conditions are met?)
Comparative analyses – why are some sites improving more than others?

PROTECTION OF BEST SITES

Identify best candidates
for **protection**

Countless ways to do this. Propose 'core components' (that apply beyond our study area) and discuss ways that existing resources, such as the BCG, B-IBI, IWI/ICI, RCP, WSIO, can be used to help prioritize sites.
Discuss key policy questions (e.g., where to invest? Public vs. private land?).
Discuss adding a CC component (what would this look like, and how would it influence prioritization?).
Discuss how this process is valuable even if local factors (e.g., land ownership) end up swamping these considerations in the end.



Stressor ID

Evaluate IWI components? Hydrologic regulation, chemistry, sediment, hydrologic connectivity, temperature, habitat; also evaluate the associated 'major stressor' StreamCat inputs? Not restricted to catchments with sampling sites.
Biology: assuming climate change is the major expected stressor, develop lists of CC indicator taxa like we've been doing for the climate pilot project



Select protection
strategy

Are certain strategies more effective than others?
Consider goals & how they are defined... our BCG work on Level 1/historic condition could be helpful here.
Also discuss how these sites are the standard against which other sites are judged; what if this bar changes due to climate change? Important to keep attainment goals realistic, yet

Adaptation design
tool?

This is a tool that was developed for corals but can be applied to streams; it takes you through a formal process (with worksheet templates) during which you consider how climate change factors into your restoration strategies.
Not sure this step is relevant here (may just be for restoration strategies)

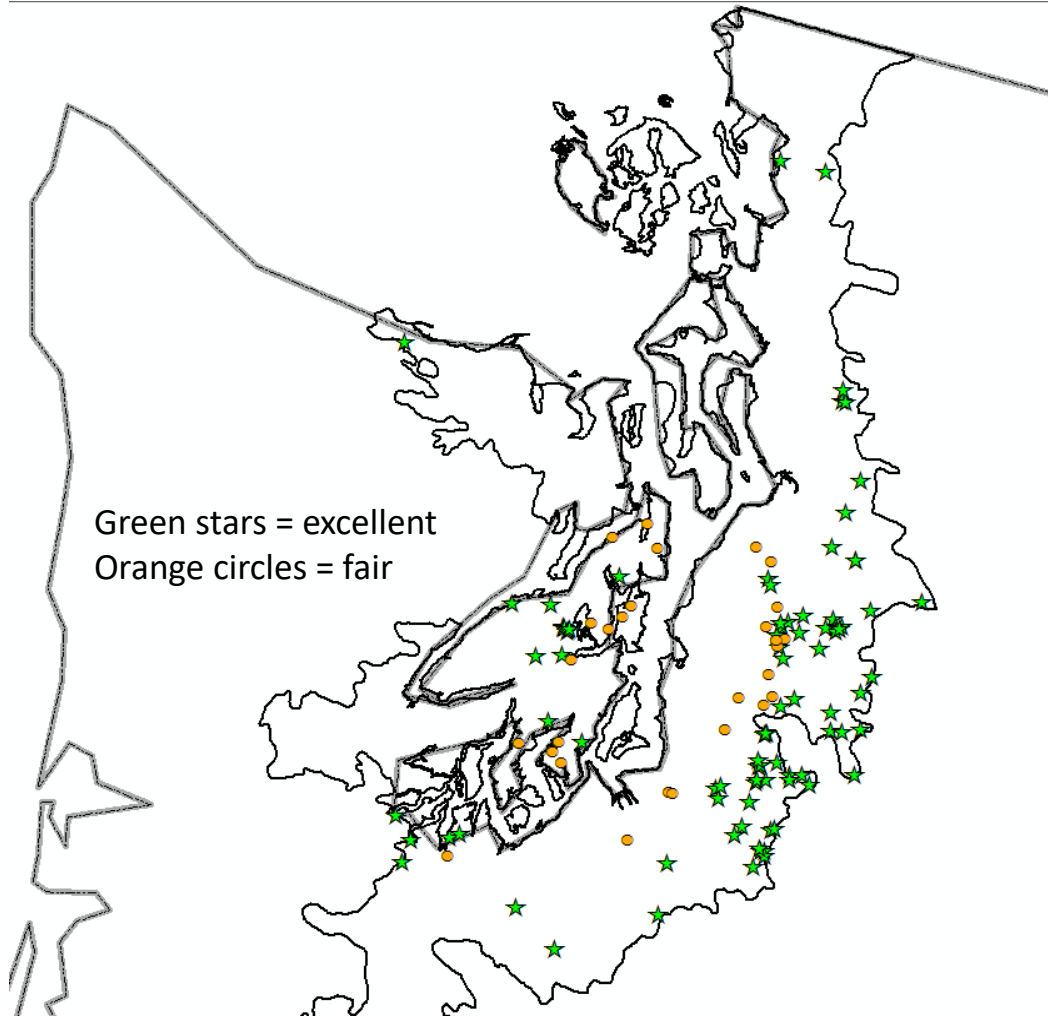


Implementation



Measure effectiveness
(with biology)

B-IBI and BCG. Too coarse for short-term indicators?
Develop specific indicator metrics for short-term indicators?
Climate change considerations too? (e.g., modify metrics to include thermal tolerance, similar to what we did for the BCG climate pilot).
Comparative analyses - evaluate what makes some sites more resilient than others.



Case study/journal article –

Tap into the multiphase project that is using Puget Sound lowland B-IBI data to help identify and prioritize streams and their contributing basins for restoration and protection. The second phase – creating more detailed assessments of stressors and developing basin-specific plans for restoration and protection – is currently underway. See Notes for links to reports on project & prioritization scheme they used. See attached Excel file for list of sites, BCG, IWI and thermal and hydrologic info (historic and future).

Bring in the new BCG model (to supplement not replace the B-IBI).

Bring in the IWI and Ryan's mapping of predictive biological condition (assuming it's far enough along in the clearance and publication process to allow for this)?

What additional information can we glean from the expert BCG panel? indicator metrics and taxa? restoration goals?

Thoughts on potential climate components

Proposed metrics - temperature

Expected response to increasing stream temperatures

Metrics used in the BCG rules

BCG metrics	Expected response
Number of highly sensitive taxa	Likely to decrease
% Attribute I+II+III taxa	
% Attribute I+II+III individuals	
Number of sensitive EPT taxa	
% Attribute V+VI taxa	Likely to increase
% Attribute V+VI individuals	

Additional metrics (not part of BCG model) to help interpret changes

Number of highly sensitive <i>cold water</i> taxa
% Attribute I+II+III <i>cold water</i> taxa
% Attribute I+II+III <i>cold water</i> individuals
Number of sensitive <i>cold water</i> EPT taxa

'Top indicator' taxa for temperature?

- Trying to limit the number of taxa on the list to keep it manageable
 - Small to mid-size streams (<30 mi²)
 - 'Representative' - found in good numbers in both ecoregions
- Sensitive cold & cool/warm taxa (Attribute I,II,III) expected to respond to temperature
- Track shifts in distributions over time (e.g., every 5 yrs), using all available regional data

Note: we're in the process of updating this list...

Order	Thermal indicator taxa (BCG attribute I, II, III)	Expected response
Ephemeroptera	cold: Cinygmula (att3) , Drunella doddsii (att2) , Attenella delantala (att2)	Likely to decrease
	cool/warm: Diphetor hageni (att3)	Likely to increase
Plecoptera	cold: Paraperla (att2) , Zapada oregonensis group (att3)	Likely to decrease
	cool/warm: Calineuria californica (att2)	Likely to increase
Trichoptera	cold: Rhyacophila narvae (att2) , Brachycentrus americanus (att2)	Likely to decrease
	cool/warm: Psychoglypha (att3)	Likely to increase
Coleoptera	cold: Heterlimnius corpulentus (att2)	Likely to decrease
	cool/warm: Cleptelmis addenda (att3)	Likely to increase
Diptera	cold: Glutops (att2) , Dixa (att3)	Likely to decrease
	cool/warm: Antocha (att3)	Likely to increase

Other cool/warm taxa being considered (however these are more tolerant and may increase in response to other stressors)

- [Malenka \(att4 stonefly\)](#)
- [Optioservus \(att4 beetle\)](#)

Proposed metrics & indicator taxa

Summer flows, high flow events, earlier spring peak flow

Exposure	Proposed metrics or indicator taxa	Expected response
Reduced summer low flows	Number of long-lived taxa (require water year-round)	Likely to decrease
	% Predator taxa	Likely to increase
More floods or high flow events	Density	Initial drop, then typically rebounds
	% <i>Baetis tricaudatus complex</i> and <i>Simulium</i> individuals	Typically high after a flow disturbance (natural or manmade)
	<i>Dolophilodes</i> (att2 caddisfly)	Likely to drop out. Any other taxa sensitive to substrate disturbance?
Earlier spring peak flows, temperatures warm sooner	Number of seasonal sensitive (Attribute I+II+III) taxa (14 taxa on list right now; 7 are from the family Ephemerellidae)	Likely to drop out? (emerge earlier)

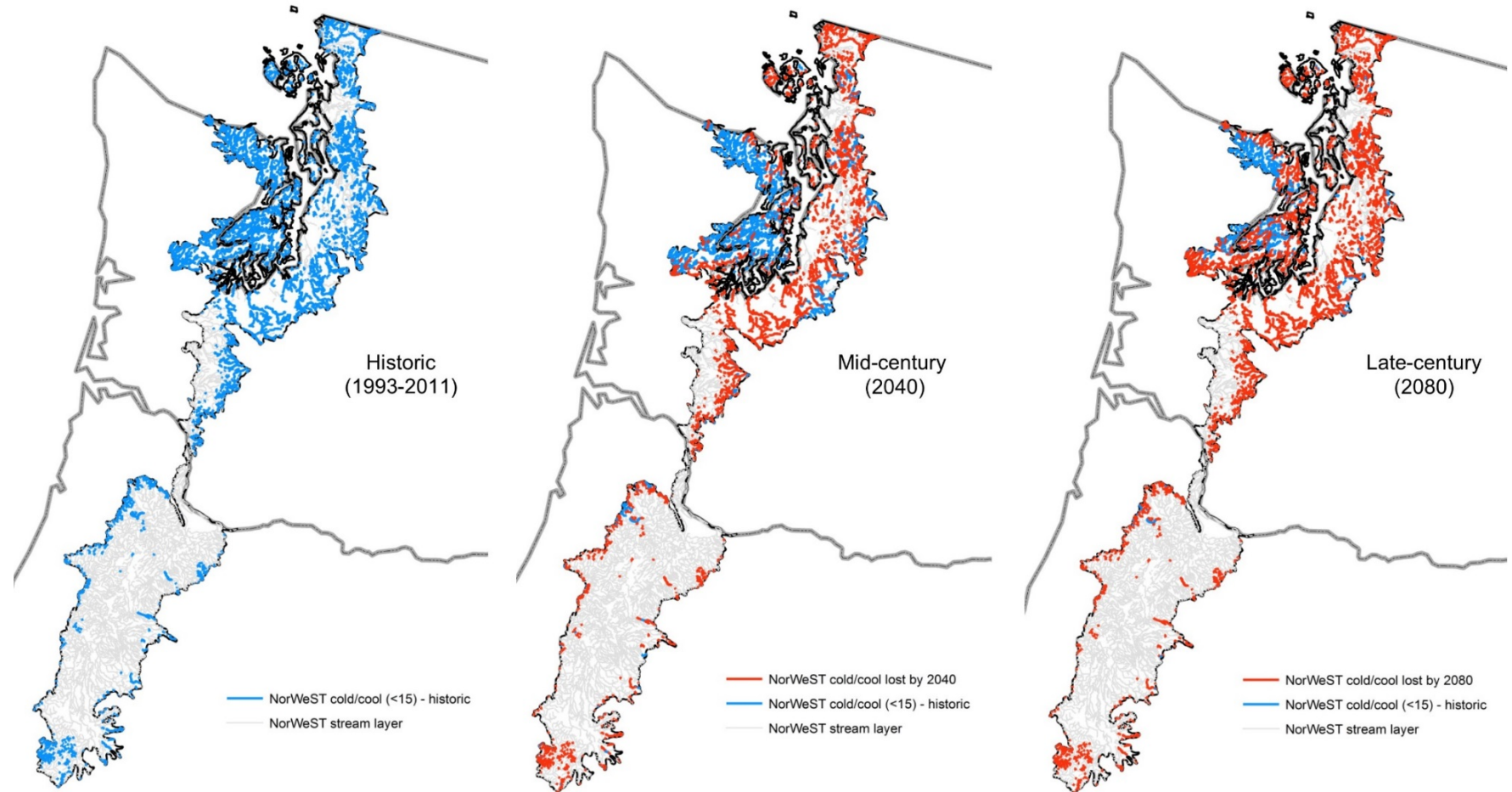
Which 'excellent' and 'fair' sites are projected to experience the greatest thermal and hydrologic change?

Identifying thermal transition areas

Cold water areas

Modeled mean August stream temperature (Isaak et al. 2015)
Cold/cool thermal habitat < 15°C

— Cold/cool (<15°C)
— Lost cold/cool (>15°C)



Setting benchmarks for biological condition

If sensitive and highly sensitive taxa drop out of BCG Level 2 sites by mid or late century due to loss of thermally suitable habitat, will we need to modify expectations for best attainable condition? (and establish a new benchmark)

Levels of Biological Condition

Natural structural, functional, and taxonomic integrity is preserved.

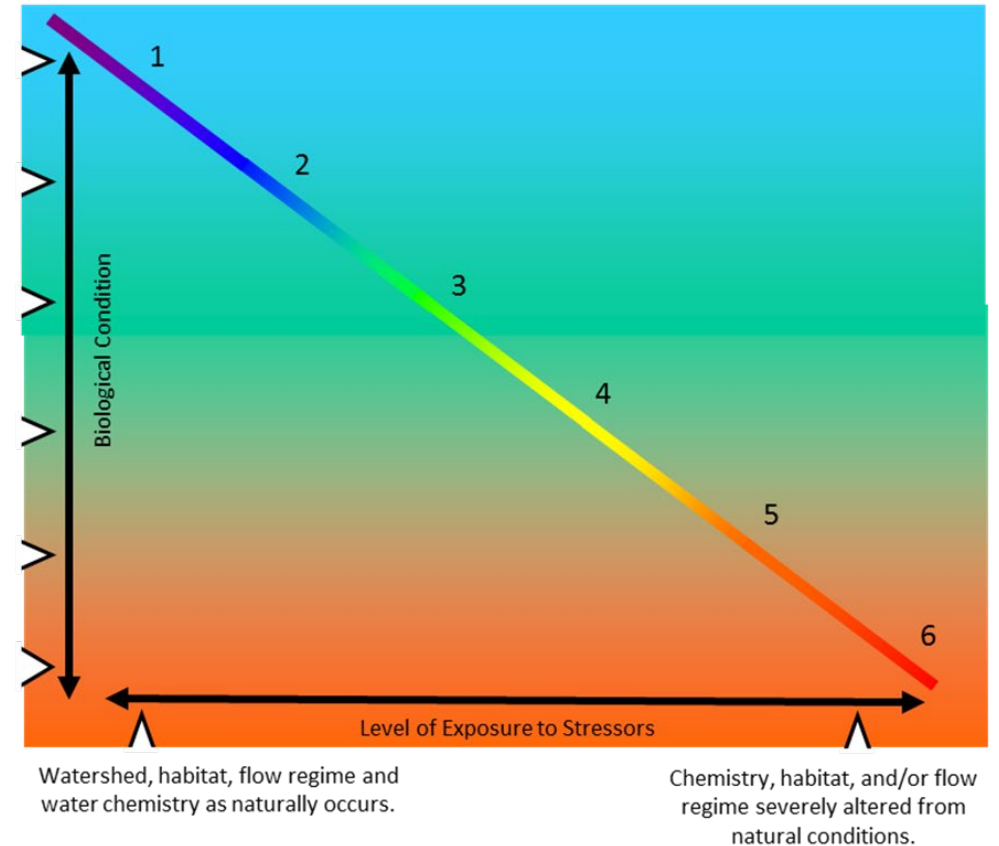
Structure & function similar to natural community with some additional taxa & biomass; ecosystem level functions are fully maintained.

Evident changes in structure due to loss of some rare native taxa; shifts in relative abundance; ecosystem level functions fully maintained.

Moderate changes in structure due to replacement of some sensitive ubiquitous taxa by more tolerant taxa; ecosystem functions largely maintained.

Sensitive taxa markedly diminished; conspicuously unbalanced distribution of major taxonomic groups; ecosystem function shows reduced complexity & redundancy.

Extreme changes in structure and ecosystem function; wholesale changes in taxonomic composition; extreme alterations from normal densities.



Interactions of CC with existing stressors (y-axis of BCG)

Urban

- More heavy precipitation events
 - More flash floods? (CC may exacerbate effects of impervious surfaces on runoff)
 - More CSOs? CC may amplify the likelihood of contaminated overland flow or combined sewer overflows (due to exceedance of capacity of drains)
- Temperature
 - More episodic spikes in stream temperature during summer rainfall events? (occurs when runoff washes over hot pavement and enters the stream) (Nelson and Palmer 2007, Hester and Bauman 2013)
- Reduced water quality
 - Toxicity – will CC exacerbate ‘first flush events’?
 - Reduced summer flows – less dilution/more concentrated pollutants?

Future urban growth

- Rising water demands – exacerbate summer low flows?
- Removal of riparian vegetation – exacerbate temperature increases (allows more solar radiation to reach the water surface, thereby directly increasing water temperature; Moore et al. 2005)

Interactions of CC with existing stressors

Agricultural

- More heavy precipitation events
 - More nutrient and sediment loading? (but also more dilution?)
- Reduced summer flows
 - Reduced water quality, due to less dilution/more concentrated pollutants?
 - Reduced flows & rising temperatures may be exacerbated by channel alterations associated with agriculture, such as widening, shallowing, or other forms of ditching (Poole and Berman 2001; Moore et al. 2005)
- Future ag growth
 - Rising water demands, due to withdrawals of water for irrigation and livestock production – will these exacerbate summer low flows & temperature increases?
 - Removal of riparian vegetation – exacerbate temperature increases (allows more solar radiation to reach the water surface, thereby directly increasing water temperature; Moore et al. 2005)

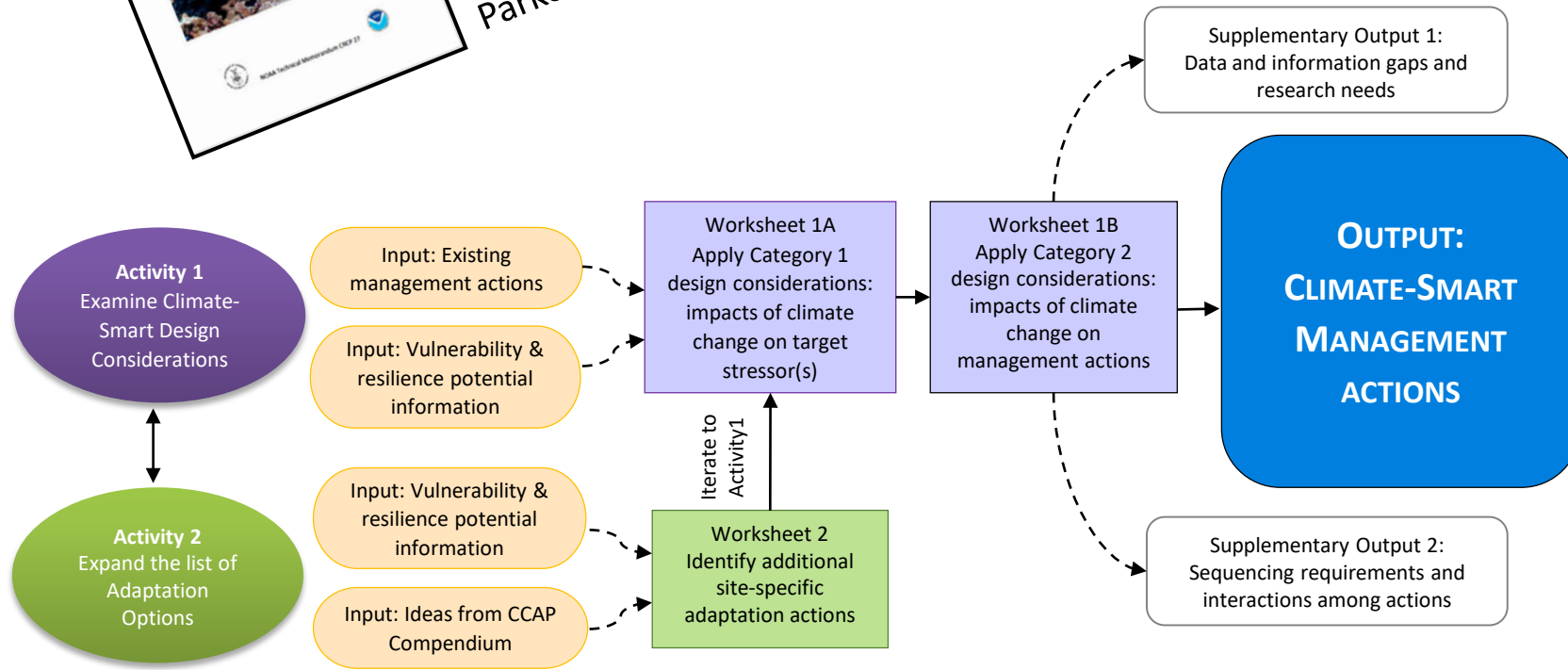
Climate-Smart Cycle with Adaptation Design Framework



CCAP Adaptation Design Tool: Flow Chart of Activities



Parker et al. (2017)



Worksheet 1A example (partial)

A1	A2	A3	A4	A	A6	A7
Action number	Existing management action	Stressor(s) of concern	Climate change effects on stressor(s): direction, magnitude, mechanism, uncertainty	Timing of climate change effects	Implications for effectiveness metrics and how to measure them	Notes
1	Plant riparian buffers along the Rio Loco where it passes through farms	<ul style="list-style-type: none"> Terrestrial sediment and nutrients 	<ul style="list-style-type: none"> Storms may become more intense, leading to precipitation events with more runoff carrying sediment and nutrients from land (SWCS 2003), especially on high slope farms along the Rio Loco. The percent increases in erosion and runoff will likely be greater than the percent increase in precipitation (SWCS 2003; Nearing et al. 2004). High magnitude, low uncertainty. Stormwater plumes may extend further into the ocean, impacting more coral reefs. High magnitude, low uncertainty. Sediment and nutrient runoff may be exacerbated by warmer air temperatures that are expected to render soils more erosion-prone (Farrell 2014). Medium magnitude, low uncertainty. Storms of sufficient intensity to release levels of sediment and nutrients exceeding reefs' tolerance may occur more frequently. High magnitude, medium uncertainty. Sediment and nutrient delivery may become more intermittent due to changing precipitation patterns. Medium magnitude, medium uncertainty. 	<ul style="list-style-type: none"> Increasingly violent storms are already occurring Mudslides have been occurring on steep slopes with greater frequency. Storm intensity will likely continue to increase over the coming decades. 	<p>Effectiveness metrics: Reduction by X, Y and Z percent of sediment and nutrient (N and P) loads originating from farms.</p> <p>Implications for effectiveness metrics: In addition to reducing monthly average loads, loads following storms will need to be reduced by a larger percentage to keep LBSP from crossing reefs' thresholds. Because reefs' LBSP thresholds may be crossed more often due to increased storm intensities, the impact of LBSP from individual storms may increase relative to the impact of chronic LBSP loads.</p> <p>Implications for how to measure effectiveness metrics: Water quality monitoring stations should be located down-channel of farms with cover crops and those without (for comparison). It will become more important to have long-term sampling that reflects extreme storms (including throughout storms). Sampling will likely need to record a broader range of LBSP loads.</p>	<ul style="list-style-type: none"> Sediment loads may need to be minimized over a multi-day timescale, while nutrients may need to be minimized over a multi-week timescale. How much are 2-, 5-, 10-, and 25-year storms expected to change by 2050? How much of a reduction in runoff from use of riparian buffers is necessary to reduce runoff to levels that reefs can tolerate in conjunction with other management measures?

Worksheet 1B example (partial)

B1	B2	B3	B4	B5	B6	B7	B8
Action number	Existing management action	Changes in effectiveness of management action due to: climate impacts on target stressor	Changes in effectiveness of management action due to: climate impacts on management action	Time frame or constraint for using the action and implementation (e.g., urgency, longer or shorter term)	What changes are needed to adapt the action (place, time, and engineering design)	Climate-Smart Management Action	Notes
1	Plant riparian buffers along the Rio Loco where it passes through farms	<ul style="list-style-type: none"> Riparian buffers may not be wide enough to slow surface runoff from stronger storms sufficiently to let sediment settle out and prevent channels through the buffer from forming. Riparian buffers may not be wide enough to allow adequate infiltration for roots to absorb dissolved nutrients. Runoff balance shift 	<ul style="list-style-type: none"> Riparian buffers may be eroded more easily by more powerful surface flows in stronger storms. Riparian buffers nearest the streams/Rio Loco may be eroded more easily by larger in-stream flows. Buffer vegetation may need to be more drought- and heat-resistant to survive and retain soils made drier by warmer air and more intermittent precipitation. Wherever the Rio Loco or its 	This can be implemented immediately. It has the potential to quickly affect sediment and nutrient loads.	<ul style="list-style-type: none"> Riparian buffer plants need to be selected for both drought and high-flow resistance. They should tolerate higher temperatures and drier soils than they currently experience. Buffer widths need to be designed to trap sediment in surface flow and allow infiltration of water with dissolved nutrients into soil during larger flows (or larger flows more frequently). It might be best to preferentially buffer ones that have larger catchments, so that more lateral flow is intercepted. But buffer locations should also consider how water flow will change across farms and in streams due to altered precipitation patterns and soil properties. Use vegetation that will send roots to soil depths that are 	Plant riparian buffers that will be an adequate width to withstand and intercept potentially larger surface and subsurface flows across farms. The buffers should be planted in locations that will intercept the maximum runoff possible (probably determined by hydrological models). Buffer plants should be able to withstand larger in-stream flows and across-farm flows, hold together drier soils, and withstand higher air temperatures with potentially longer dry periods.	<ul style="list-style-type: none"> Where are the best places to plant buffers (particular farms and locations in farms)? What would be good buffer plants at high altitudes and steep slopes? How can we get buy-in from farmers for this effort? How will balance of runoff shift between surface and sub-surface? River restoration in these areas would provide a larger